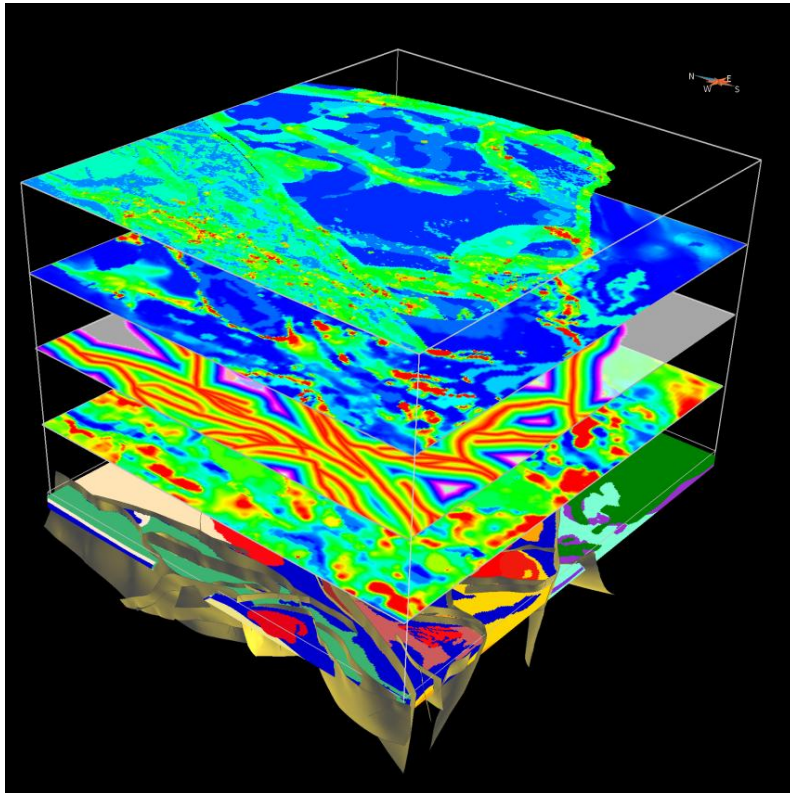


# Regional 3D Mineral Potential Modelling using Geology and Geophysics

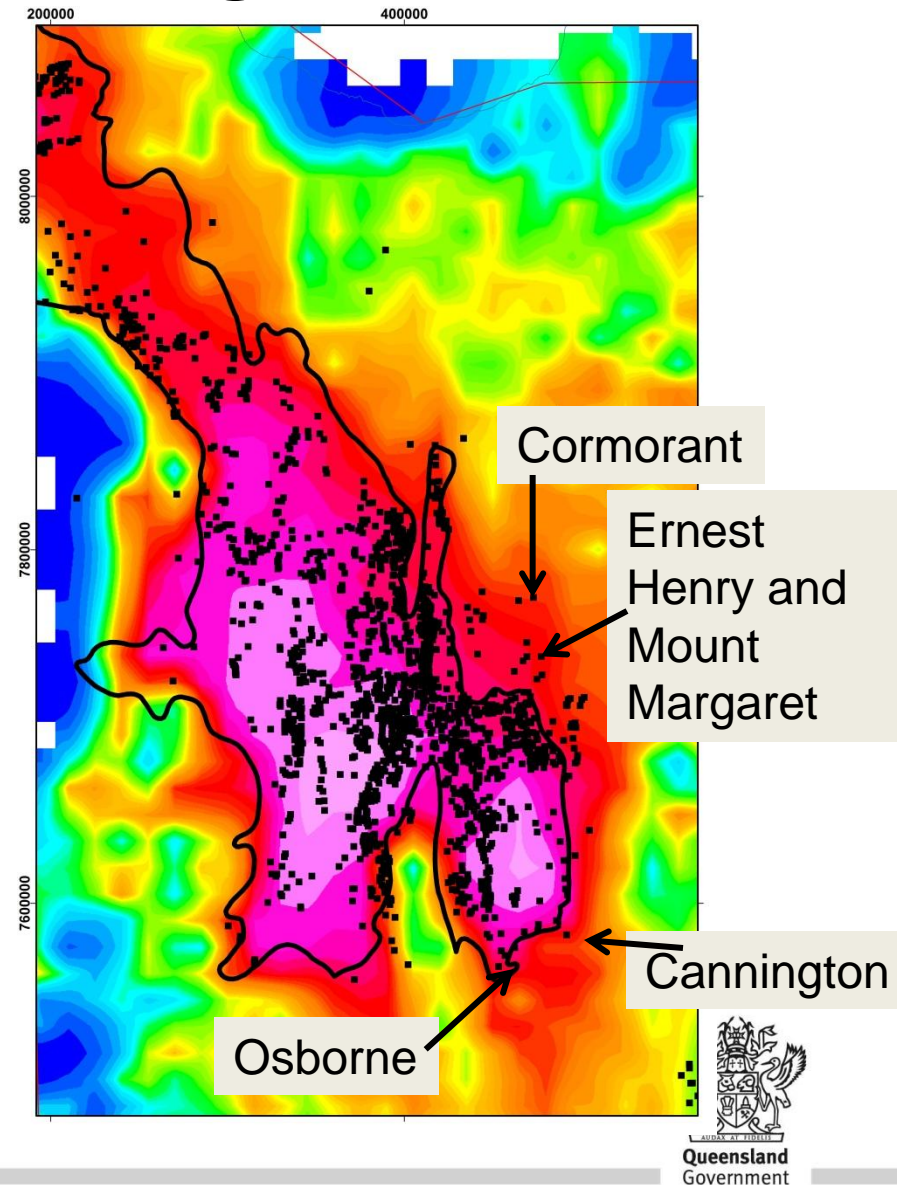


**Matthew Greenwood**  
**Courteney Dhnaram**

**Greenfields Prospectivity Unit**  
Geological Survey of Queensland  
Department of Natural Resources and Mines

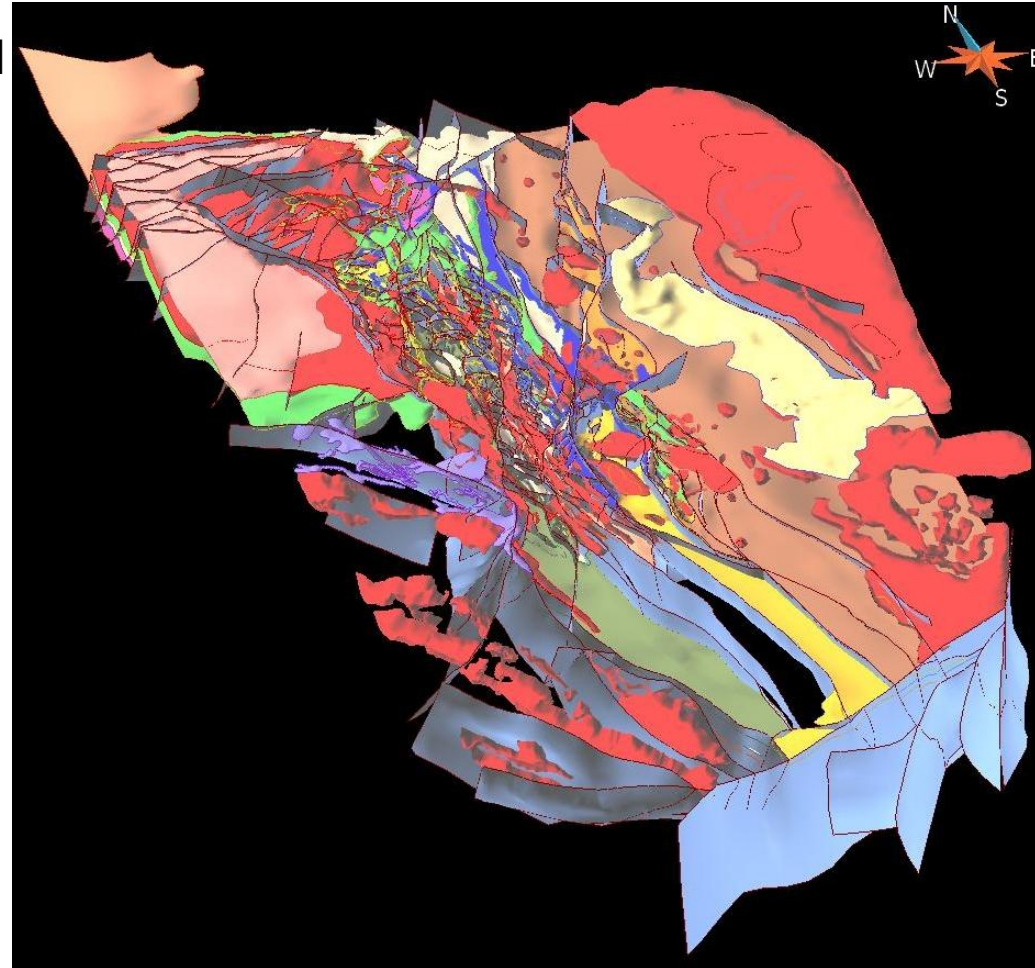
# The Challenge

- Similar to most of Australia, >80% of Queensland is concealed by cover rocks (<5m to >1km)
- The next step is to extend inventory of known resources into the covered region
- The next generation of giant deposits awaits discovery !
- How do we encourage that exploration?



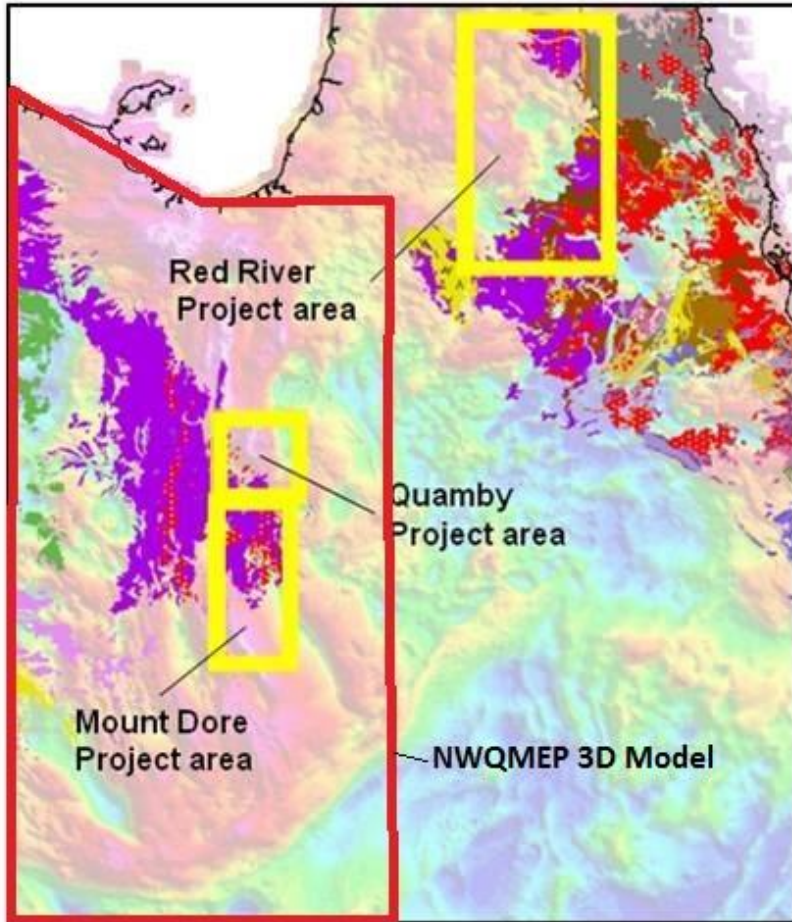
# Regional Scale 3D Modelling

- North-West Queensland 3D model
- Extends from the western border of Queensland toward Georgetown AND covers over 500,000km<sup>2</sup> to 20km depth.
- Integrates numerous geophysical and geological datasets.
- Key Aims:
  - Link outcrop understanding with surrounding undercover regions
  - Define major crustal breaks and potential fluid conduits
  - Provide a broad architectural framework to underpin future more detailed studies



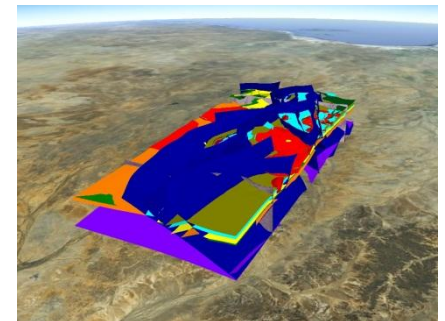
# Prospectivity Studies

*Designed to attract exploration investment, reduce risk and improve land use decisions*



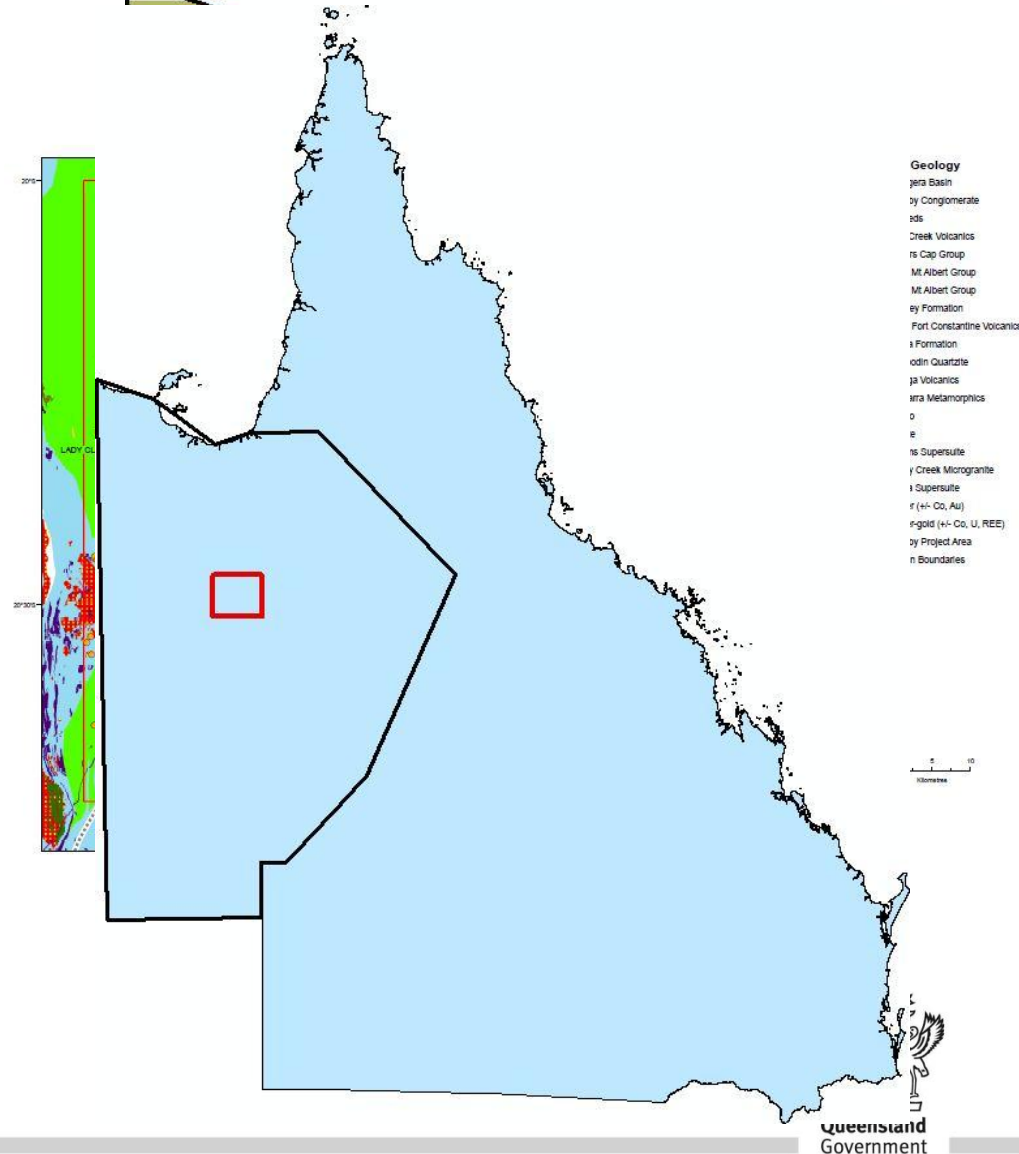
**Regional syntheses, models and assessments**

**Targeted district 3D studies**



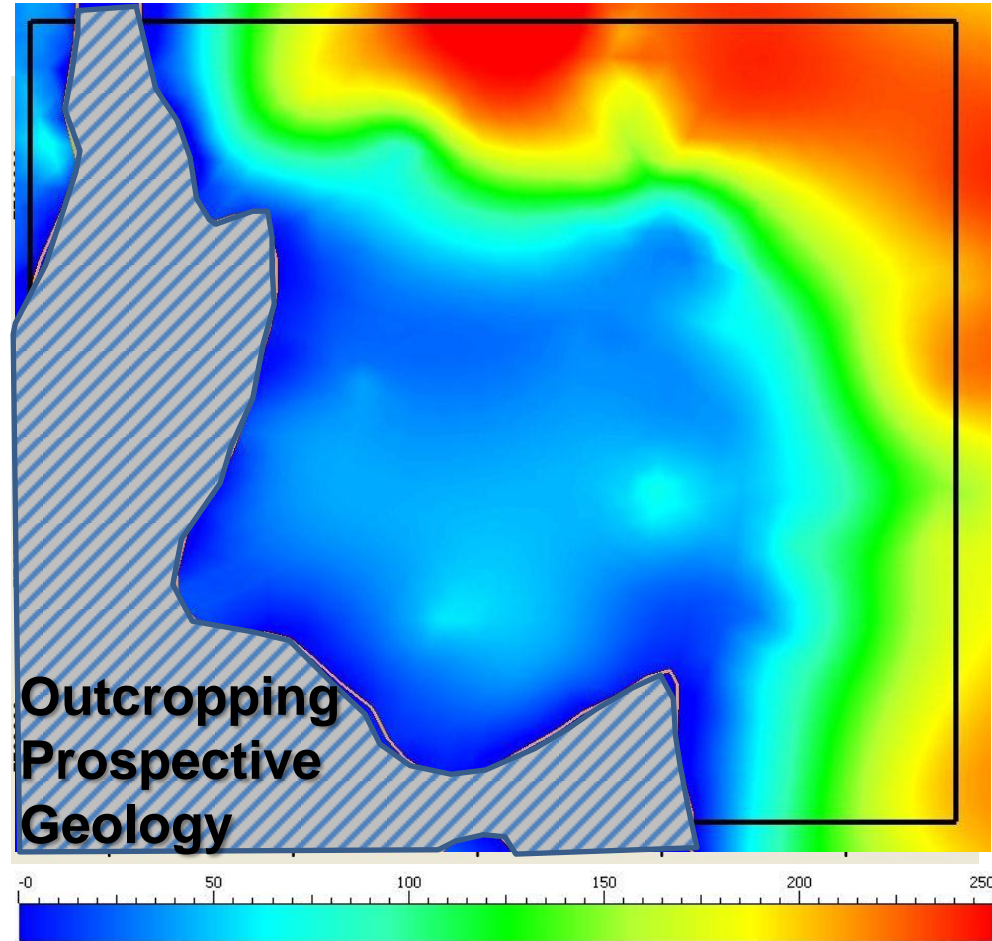
# Quamby Project Area

- Project area covers an area of 95km long by 80km wide. Located immediately north of Cloncurry and Mt Dore project
- Includes the major operating Ernest Henry copper - gold mine as well as significant copper and gold projects such as Rocklands and Roseby, and the Dugald River Silver – Lead – Zinc deposit



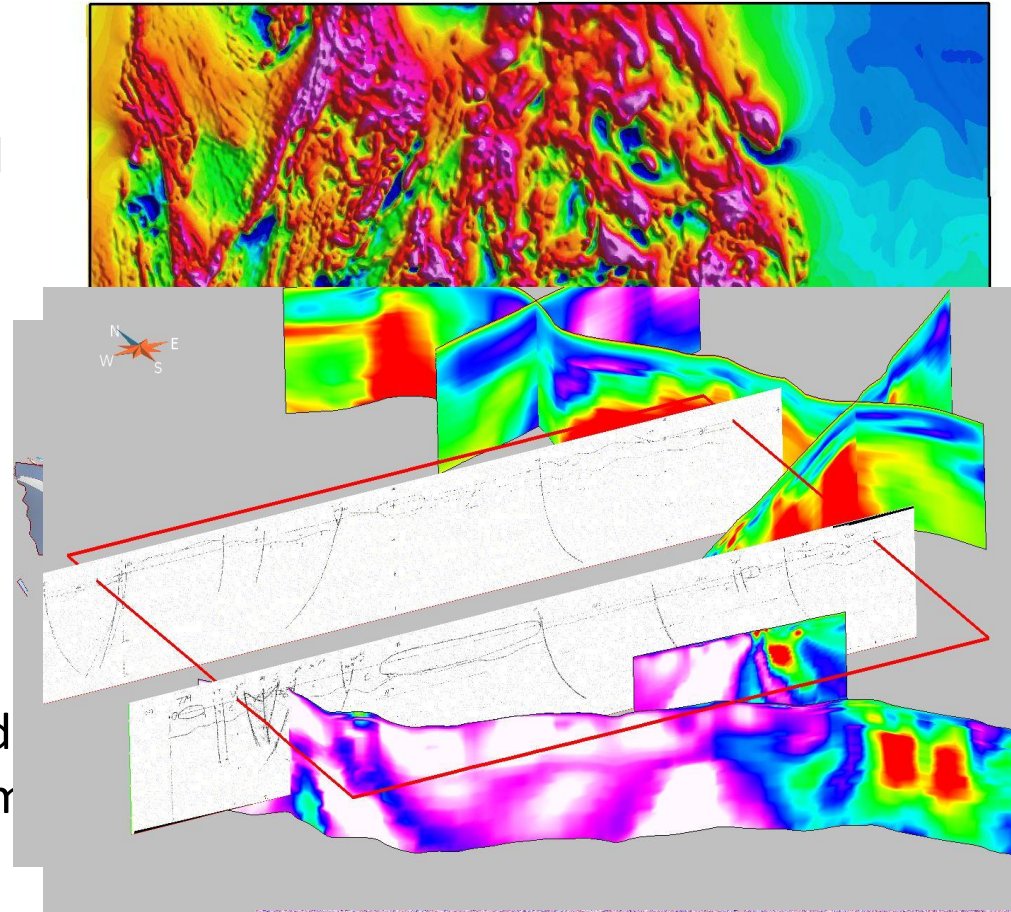
# Mineralisation Potential

- Sediments cover >70% of the area. However, most cover depths interpreted to be less than 200m. Consequently, much of the area has been under-explored.
- Quamby area is prospective for multiple styles of mineralisation
- Known mineralisation mostly confined to outcropping areas. But some large systems discovered under shallow cover. High potential for greenfield discovery



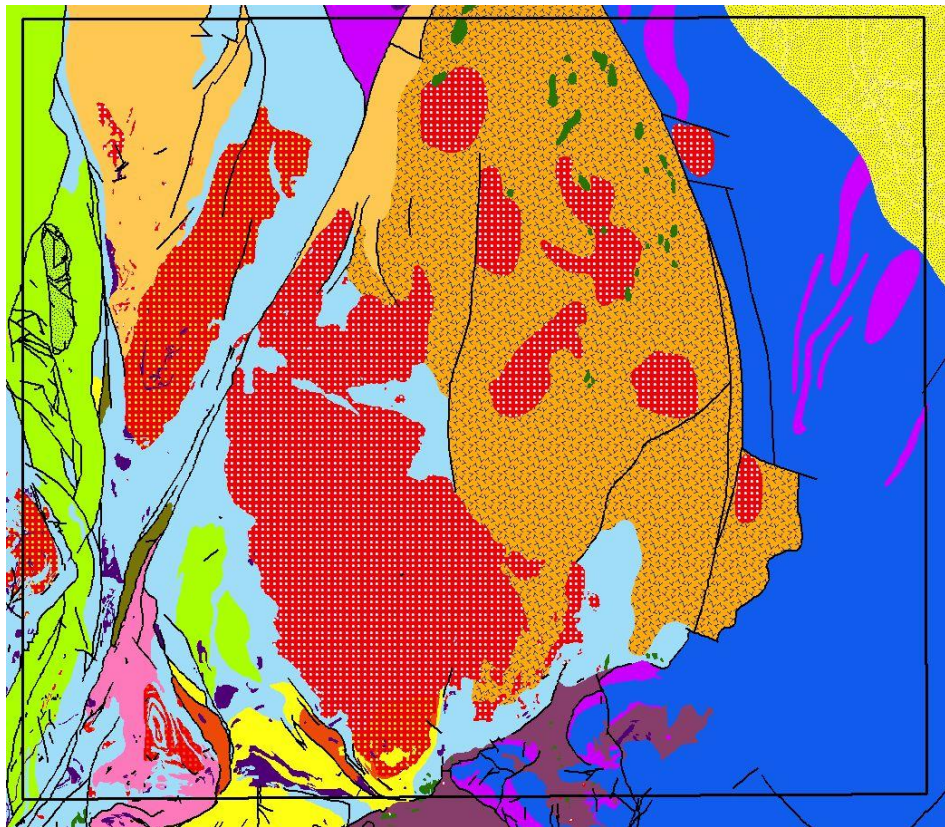
# Input Datasets

- All Open File data - publicly available
- New NWQMEP solid geology and MINOCC mapping.
- Company and GSQ/GA Gravity
- Company and Government Magnetic data
- Fault and horizon surfaces from 2010 NWQ 3D Model
- GSQ/GA Deep Seismic
- Cross-Sections created from solid geology mapping and results from NWQMEP report
- GSQ Magnetotelluric Surveys conducted along seismic profiles



# Modelling Workflow

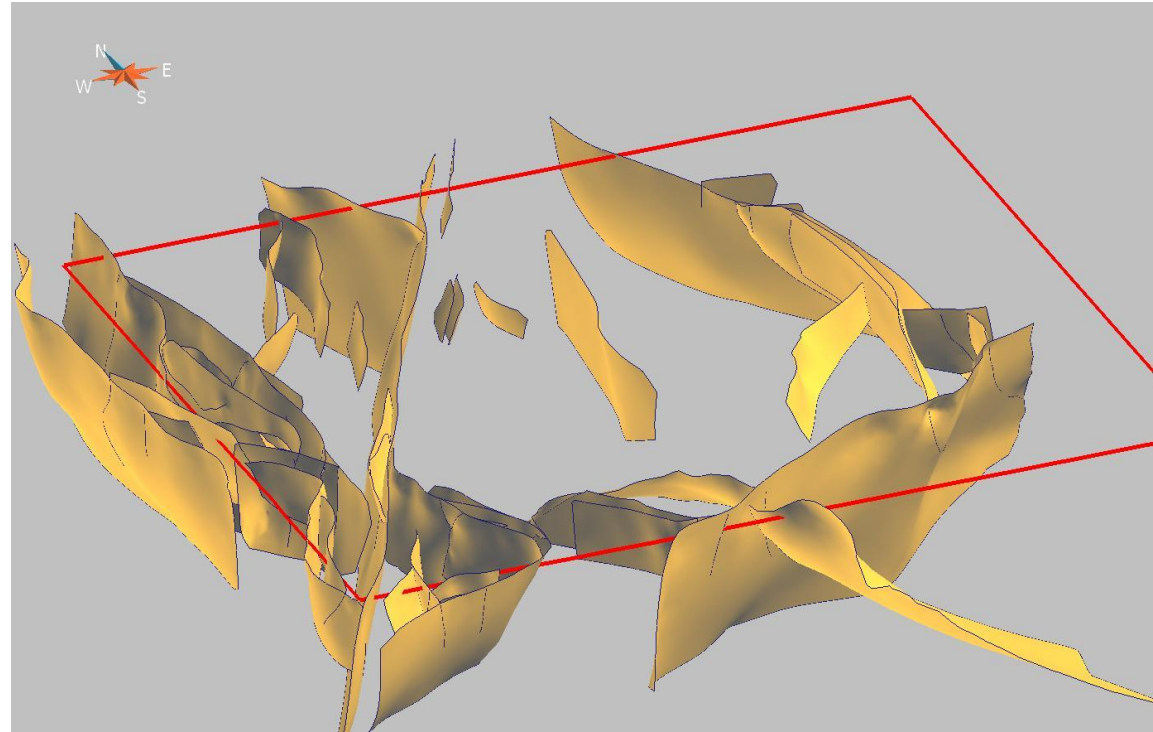
- Mapped lithologies were simplified into broader groupings based on their geological and geophysical properties and significance for modelling.





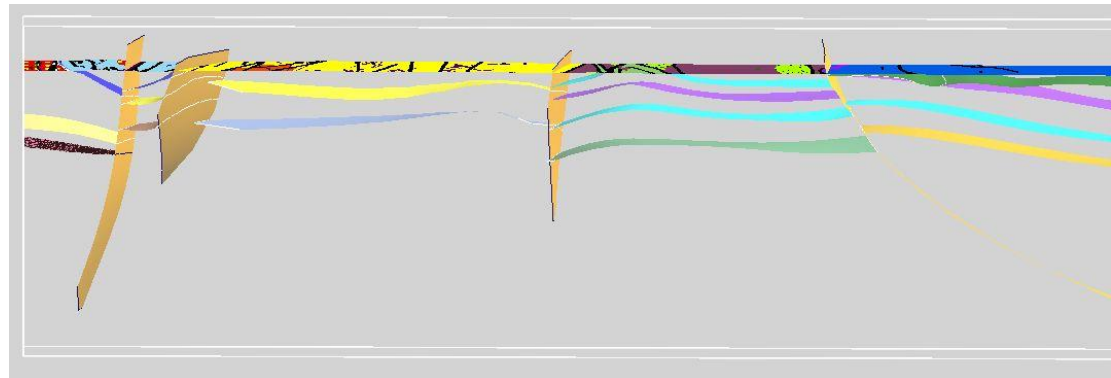
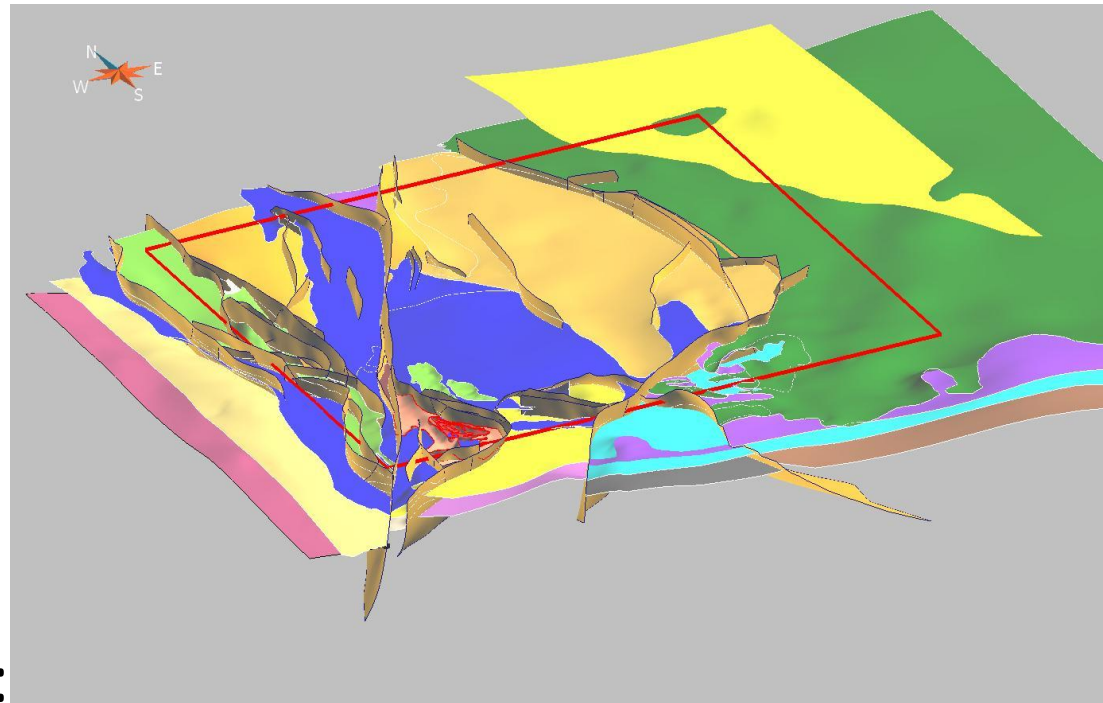
# Modelling Workflow

- Cross-Sections created from mapping, seismic data, magnetotelluric data, potential field data and filters, worms (multi-scale edge detection).
- 3D fault model created in SKUA from all available information.

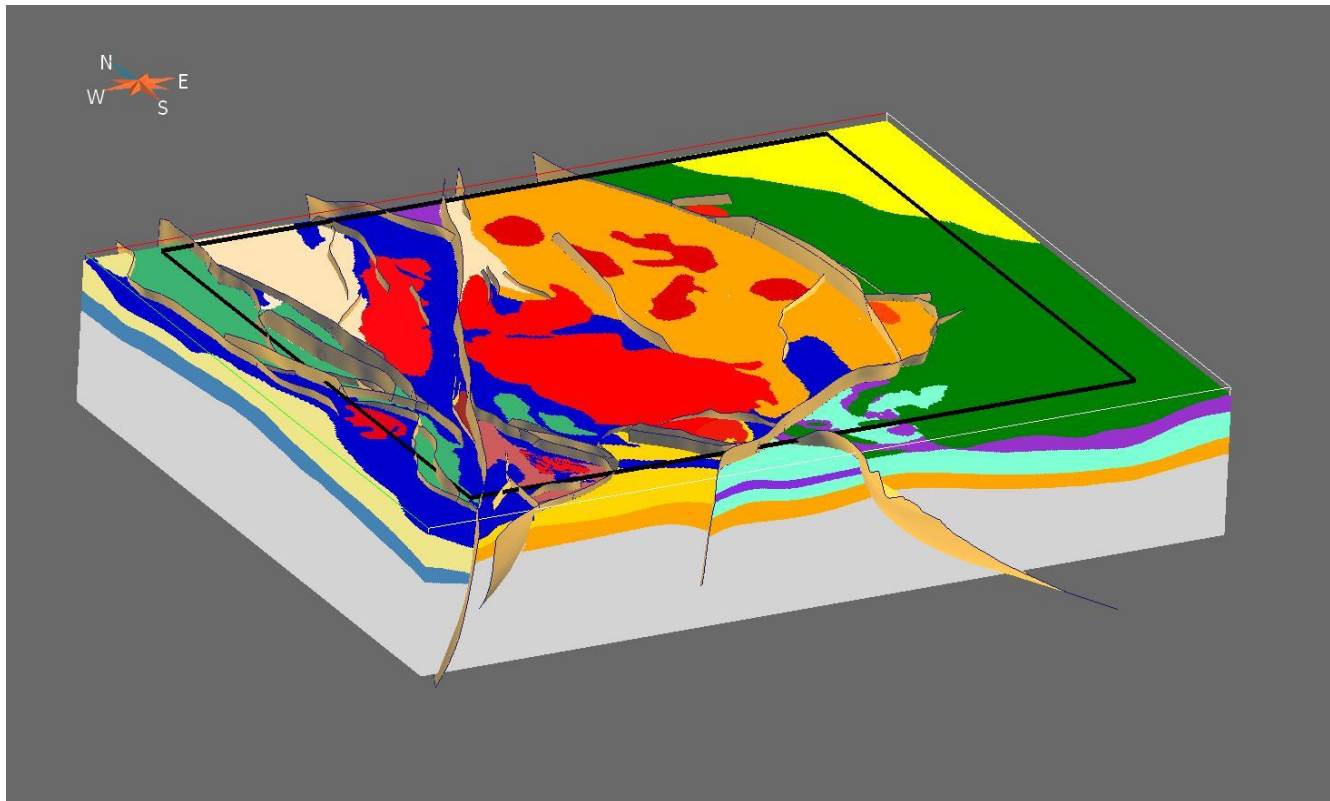


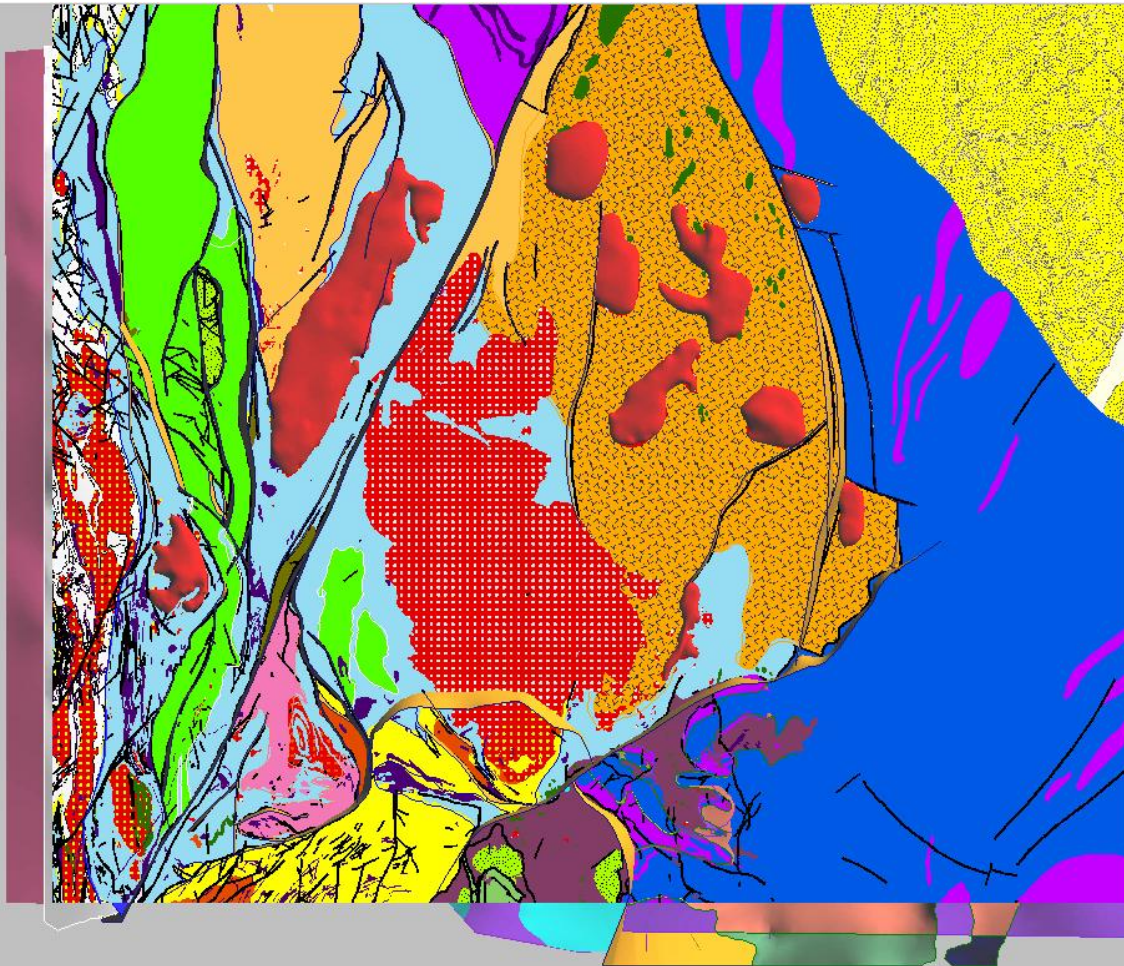
- 3D Lithology Surface modelling
- Surfaces representing base of lithological packages built in GOCAD/SKUA from:

- Seismic
- Cross-sections
- Mapping
- Potential Fields



- The 3D surface model (vector model) is discretised into a 3D voxel model (raster model) to facilitate geophysical inversions and 3D weights of evidence modelling.



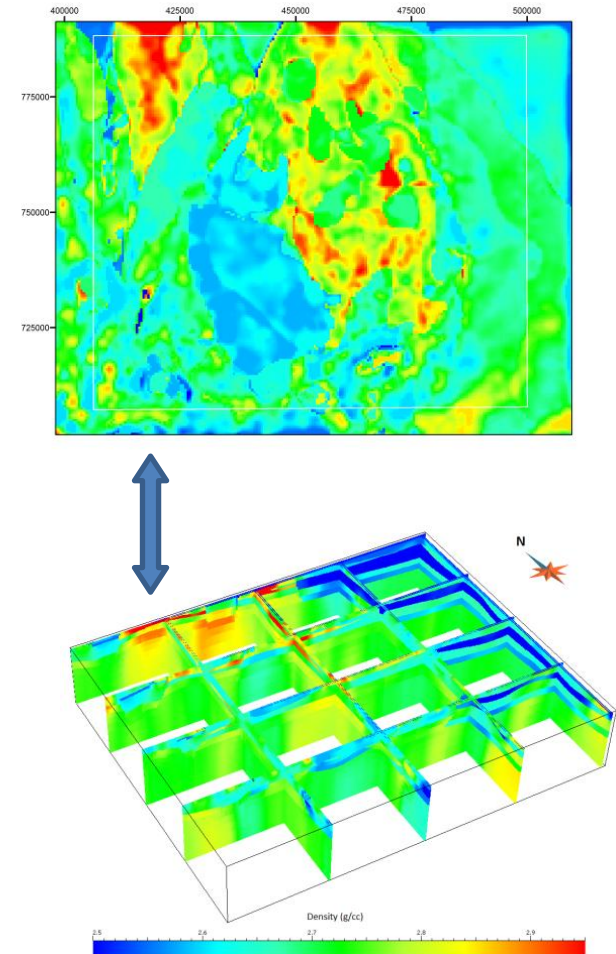


Great state. Great opportunity.



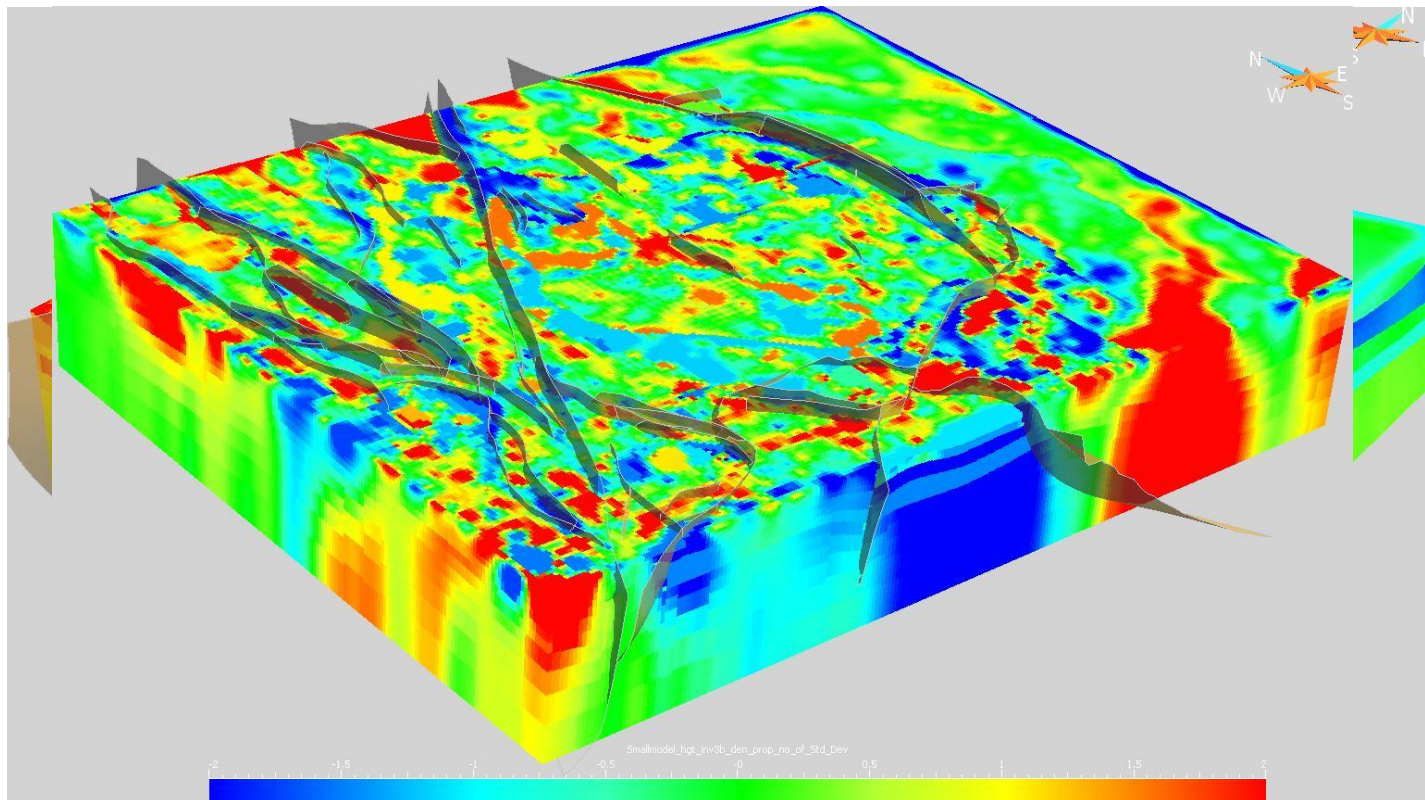
# Potential Field Inversions

- Discretised voxel populated with available physical properties (density and magnetic susceptibility) collected in field, calculated in laboratory or from literature.
- Homogenous Property Inversion of magnetic and gravity data to optimise values of properties
- Resultant optimised magnetic and gravity distributions subjected to Heterogeneous Property Inversion.
- Local anomalies, where model can't account for observed response, may represent alteration along fluid pathways, concentrations of dense and/or magnetic rock (Ore?) etc...



# 3D Density model

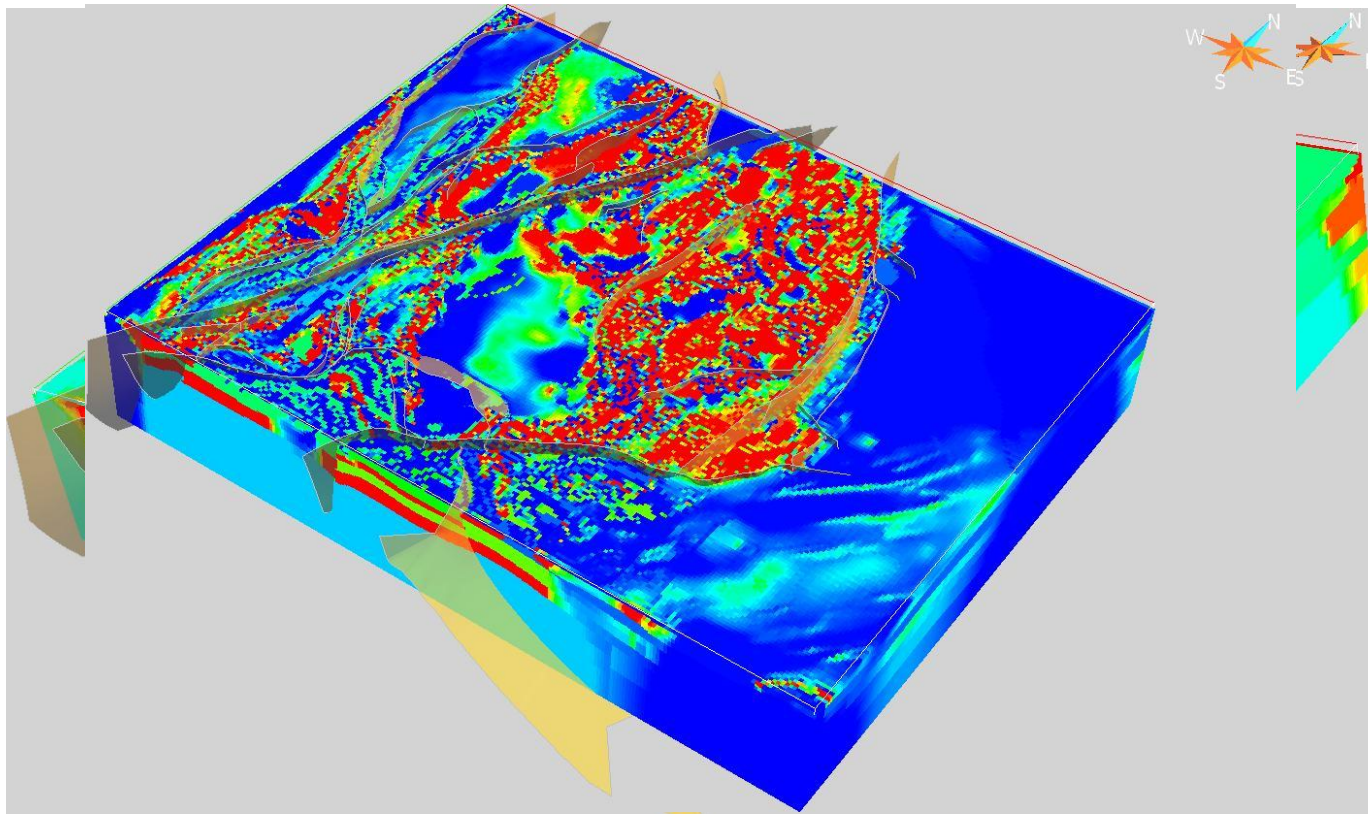
- Final 3D density model result of several generations of iterative inversion  
Constrained by geological model and the set density range of the units



Standard deviations from mean unit density (Red – Higher than expected, Blue – Lower than expected.)

# 3D Magnetic Susceptibility Model

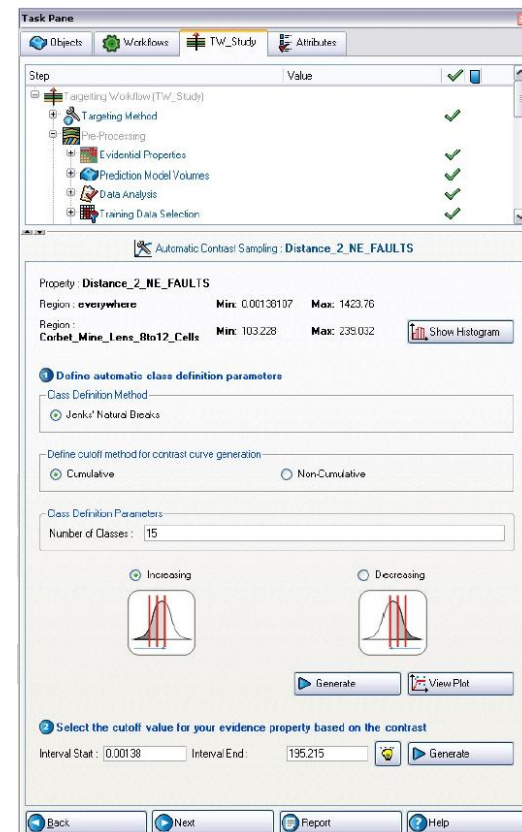
- Final 3D magnetic susceptibility model result of several generations of iterative inversion. Constrained by geological model and the set magnetic susceptibility range of the units



Standard deviation of Final 3D Magnetic Susceptibility Model

# 3D Weights of Evidence (WoE) Targeting

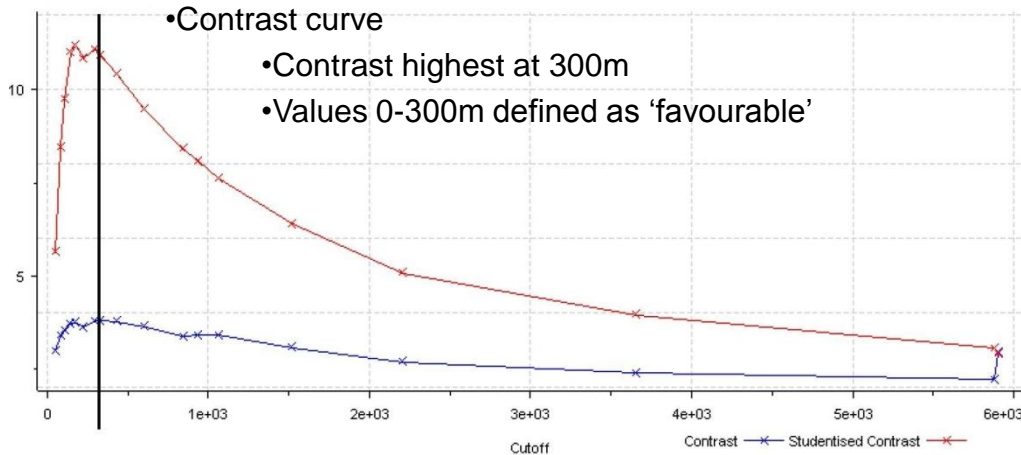
- Statistical evaluation of spatial relationships between known mineral occurrences and other spatial datasets (evidential properties/exploration criteria such as rock type, structure, geochemistry) → used to define **mineral potential probabilities**
- Mineral systems analysis and literature review undertaken as part of NWQMEP study identified exploration criteria believed to be associated with Copper and/or Gold mineralisation in area.
- Exploration criteria represented in the Common Earth model in GoCAD as continuous or discrete variables (evidential properties)
- GoCAD Targeting workflow used to assess the correlation of these evidential properties with known mineralisation (training data).



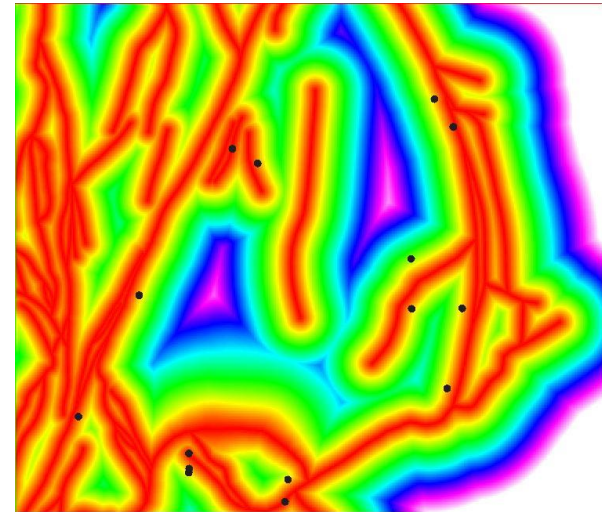


# 3D Weights of Evidence

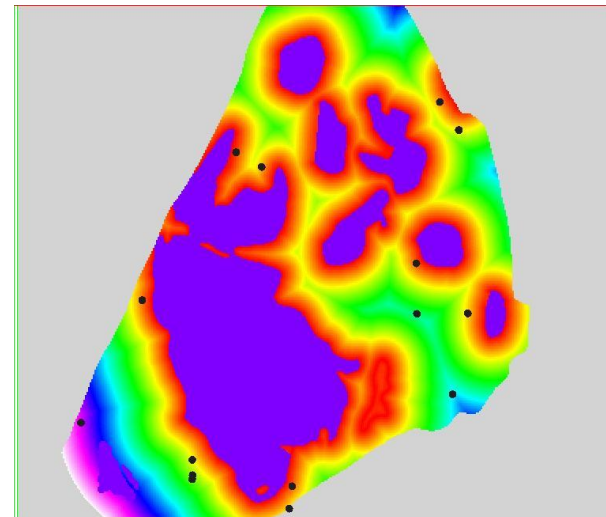
- Weights ( $W+$  and  $W-$ ) assigned from correlation between training cells and evidential properties.
- Continuous evidential properties converted to binary properties by locating the 'cut-off value', that with the maximum contrast value
- Contrast is defined as the difference between the  $W+$  and  $W-$ , higher Contrast greater discrimination.



Great state. Great opportunity.



Distance to Crustal Scale Faults



Distance to Granites

# 3D Weights of Evidence

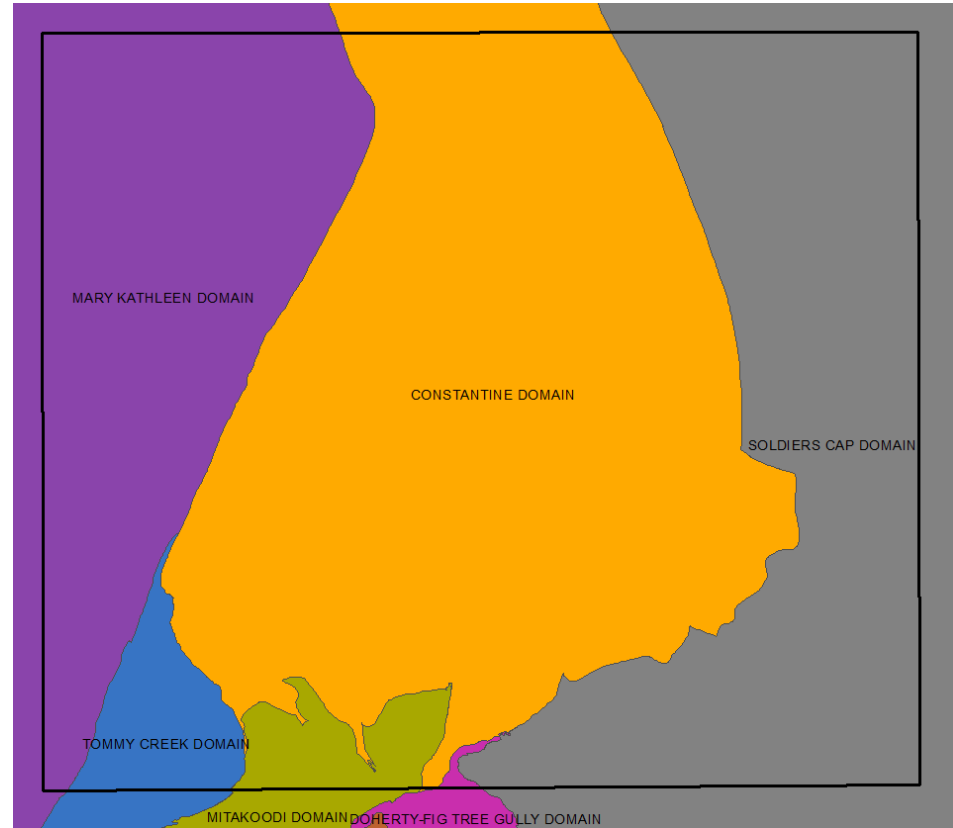
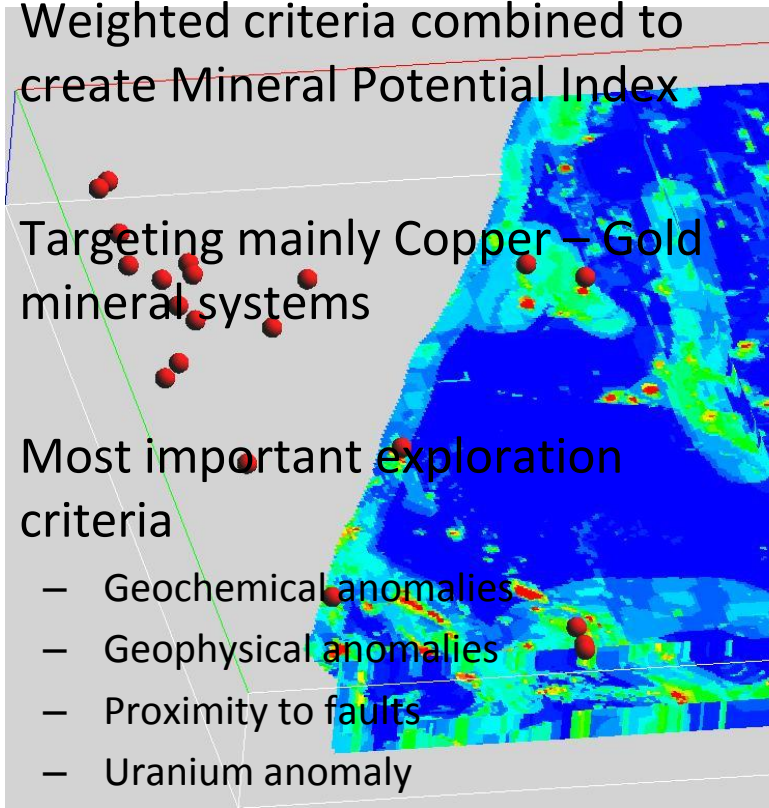
- WoE modelling completed on top 2.5 km of model
- Different exploration criteria, contrast and cut-off values across the geological domains due to different mineralisation styles, expected targets and depth of cover.

Evidential Property	W+	W-	Contrast	Stud. Contrast
Geochemistry Au	3.73	-0.75	4.48	8.65
Geochemistry Cu	3.78	-0.62	4.40	8.51
Fault Curvature	1.38	-0.32	1.70	3.10
Density Deviation	1.52	-0.52	2.05	3.95
Distance to Williams Granite	0.47	-0.56	1.03	1.87
Distance to Faults	0.89	-2.22	3.11	3.01
Magnetic Susceptibility Deviation	1.65	-0.43	2.08	3.95
Structural Complexity	0.54	-0.39	0.94	1.81
Uranium / Thorium	1.74	-0.35	2.09	3.81

- WoE models completed for two main domains, Canobie in centre of model and Mary Kathleen in west of model to find favourable mineral potential locations in each.
- Tested 23 evidential properties (including some combinations/variations:  
Inverted density/Mag Susc, variation from mean/ median of unit, number of standard deviations from unit mean.  
U/Th, U<sup>2</sup>/Th

# Mineral Potential Index – Constantine Domain

- Weighted criteria combined to create Mineral Potential Index
- Targeting mainly Copper – Gold mineral systems
- Most important exploration criteria
  - Geochemical anomalies
  - Geophysical anomalies
  - Proximity to faults
  - Uranium anomaly



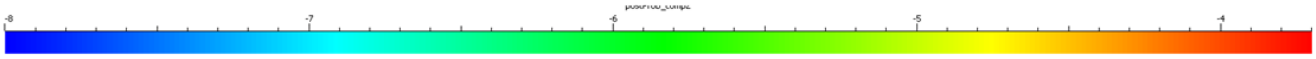
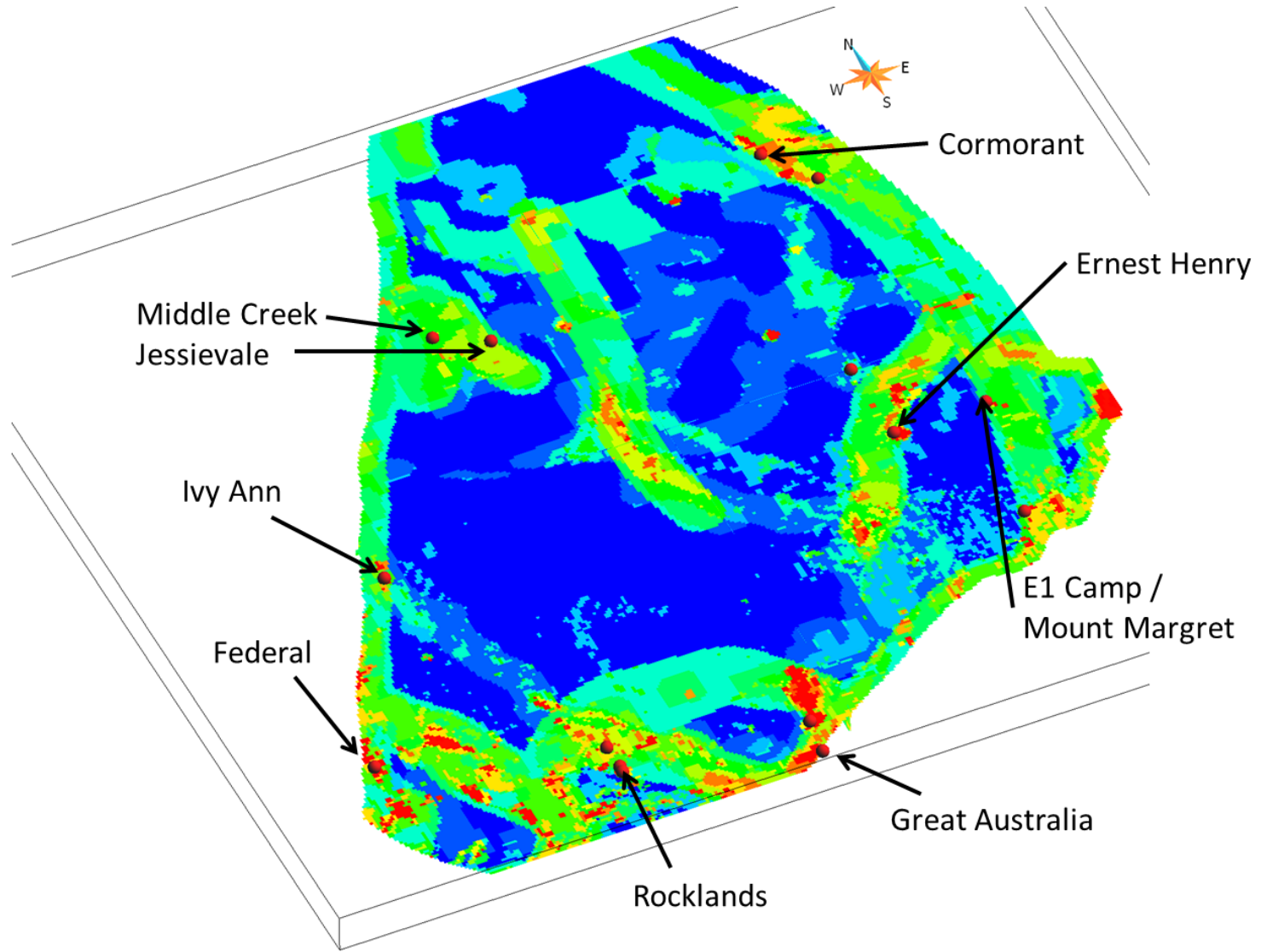
Horizontal slice at 100  
Horizontal slice at 120

Red Spheres are known mineral occurrences

---

**Great state. Great opportunity.**



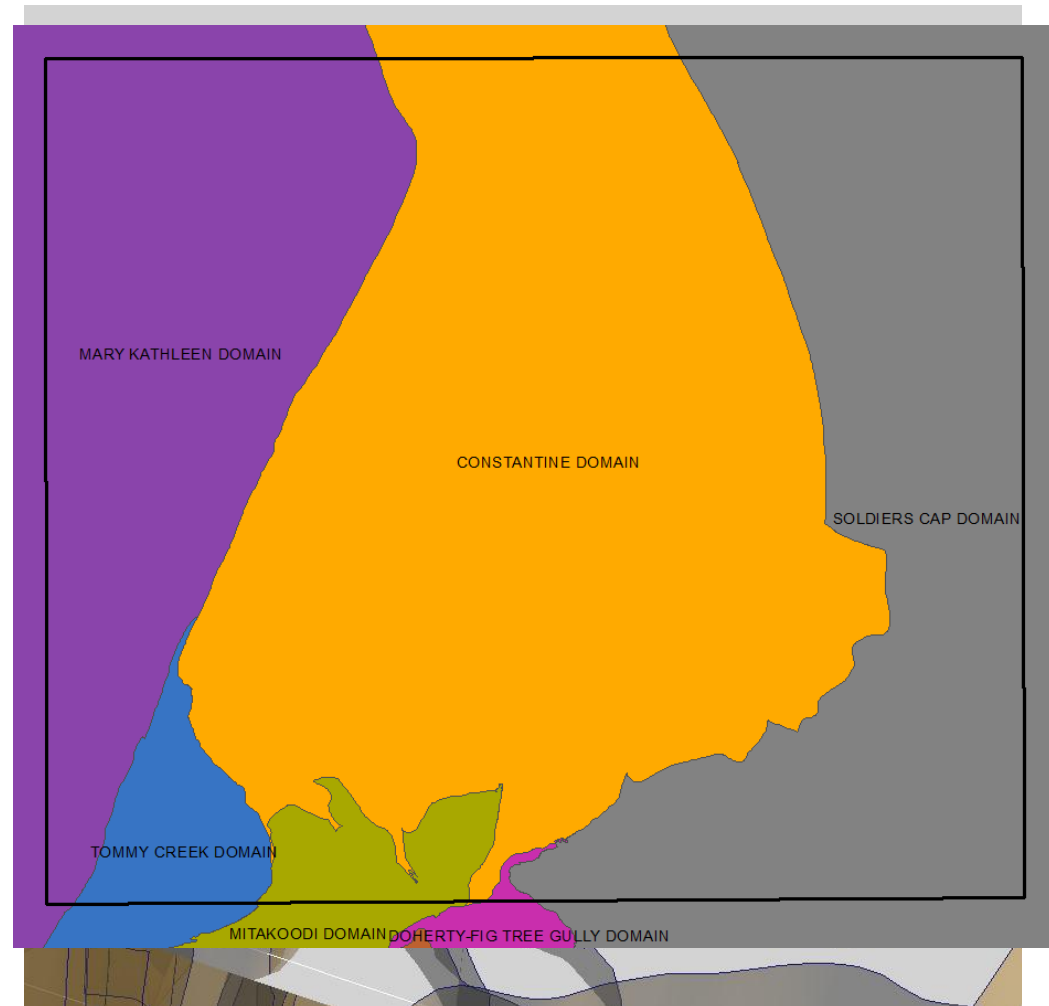


Great state. Great opportunity.



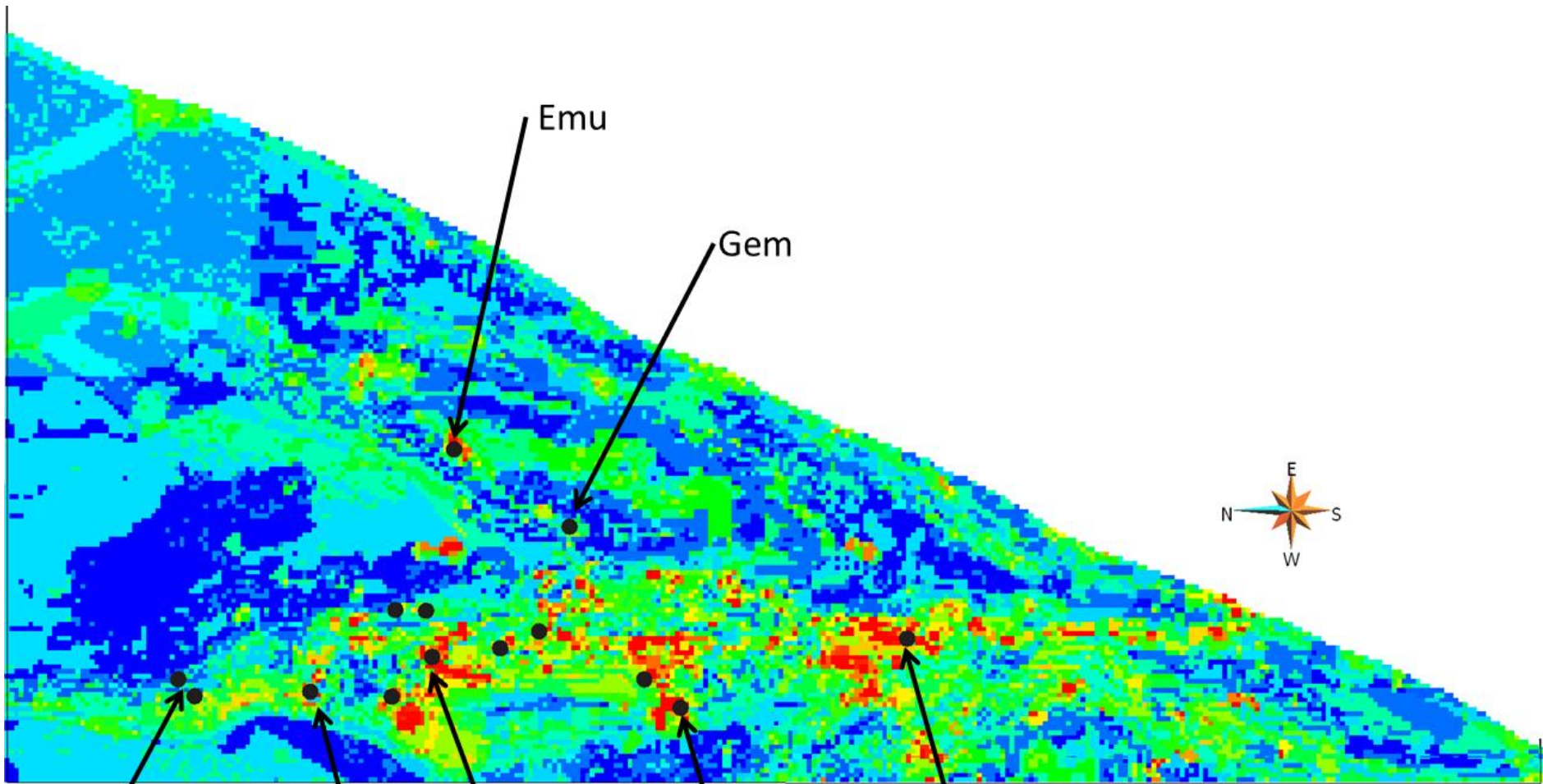
# Mineral Potential Index – Mary Kathleen Domain

- Targets include
  - Copper-Gold mineralisation
  - Copper only
- Most important exploration criteria
  - Geochemical anomalies
  - Geophysical anomalies
  - Proximity to faults
  - Potassium anomaly
- Different strengths of association
- Less variation in 3D than in Constantine Domain



Great state. Great opportunity.





Queen Sally

Little Eva

Blackard

Lady Clayre

Native Companion

Emu

Gem

Great state. Great opportunity.

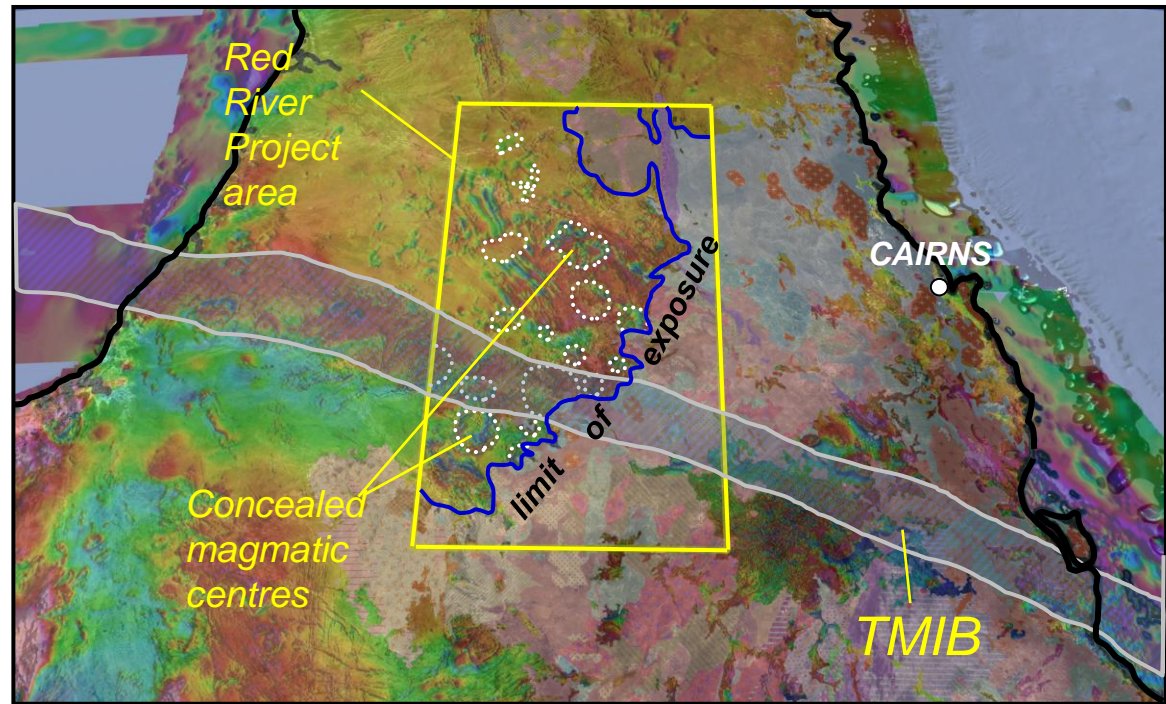




# Red River Project

- Part of North Queensland Strategic Metals Project
- Red River project area is 310 km tall by 170 km wide
- Targeting buried prospective Permo-Carb magmatic systems

- Prospective for:
  - Intrusion related gold
  - Epithermal gold/silver
  - Porphyry Mo-Cu-Au
  - Uranium and Rare-Earth Elements



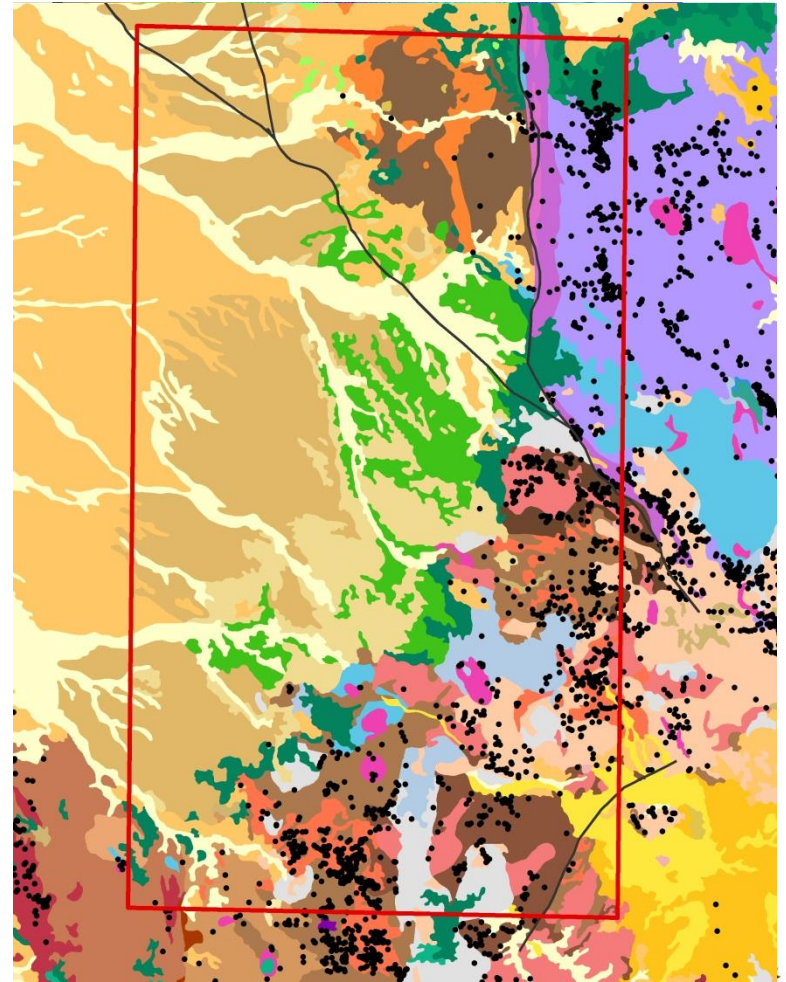
# Red River Project

- Field Work 2013
- Collecting samples for magnetic susceptibility and density measurement for input into geophysical inversions.
  - Focus on Permo-Carb granites and volcanic units in exposed areas to assess those uncovered
- Collecting orientated core sample to better understand the degree of remanent magnetisation in volcanics / intrusives



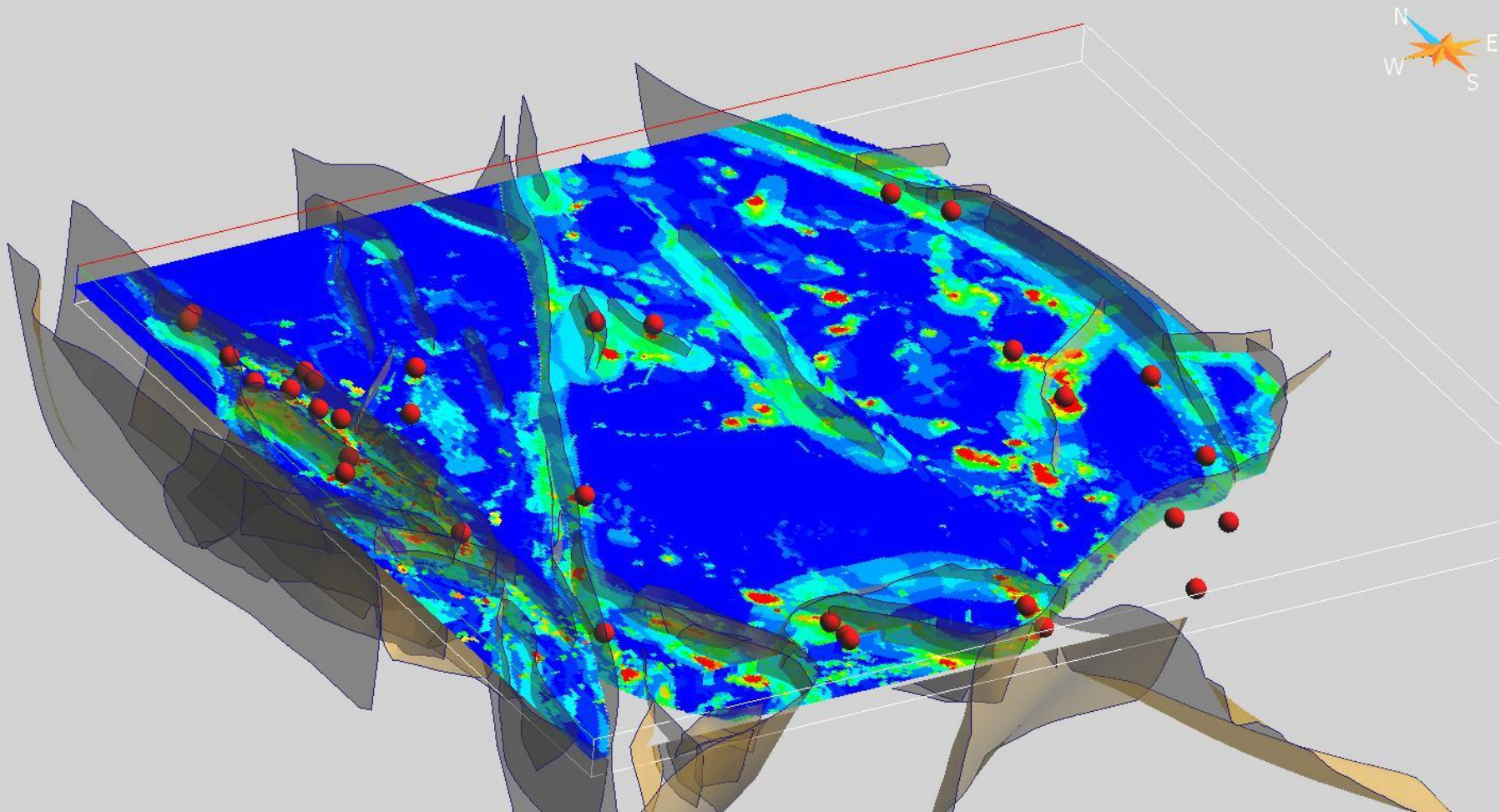
# Red River Project

- Current work on Red River Project has involved:
  - Simplification of outcropping mapped geology
  - Geophysical interpretation of covered regions of project area
  - Construction of solid geology of project area from the geophysical interpretation
  - Depth to Basement model / surface (Blue Regions are outcropping, red maximum depth 1200m)
  - Construction of a physical properties database from field samples and literature



# Conclusions

- The creation of 3D models, geophysical inversion and mineral potential modelling is value-adding to the large set of pre-competitive data available to explorers from the GSQ.
- These products aim to
  - *Attract exploration interest, ideas and investment*
  - *Reduce risk and improve efficiency exploration by defining areas of high and low interest*
  - *Improve exploration strategies and landuse decisions*
  - *Encourage new greenfields exploration*



Great state. Great opportunity.

